BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B69 10030

SUBJECT: Discussion of Proposed Changes to the Communications Systems of the AM and ATM in AAP - Case 620

DATE: October 10, 1969

FROM: A. G. Weygand

new-417

ABSTRACT

The advantages and disadvantages of modifying the current design of the communications systems of the Airlock Module (AM) and the Apollo Telescope Mount (ATM) in either of the two manners as recently proposed by MSFN are discussed. In one proposal, the AM would be provided with an S-band receiving system and the capability to receive up-data signals for both the AM and ATM up-data systems. In the second proposal, the AM would be provided with a Unified S-Band system which would provide the Orbital Assembly (OA) with all of the required real-time and delayed-time communications and tracking capabilities. It is the opinion of the writer that neither one of these two proposals should be implemented on the first workshop. However, consideration should be given to the implementation of an integrated telemetry system for the first and/or second workshops which would integrate the data from the workshop and all modules docked to it (OA) during any part of its mission into two PCM telemetry bit streams, one containing all of the real-time data and the second containing all of the delayed-time data from the OA.

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MEMORANDUM FOR FILE

1.0 INTRODUCTION

The advantages and disadvantages of modifying the current design of the communications systems of the Airlock Module (AM) and the Apollo Telescope Mount (ATM) and of modifying the current plan for operation of the communications system of the Command and Service Module (CSM) when docked to the Saturn V Workshop (SWS) in the Apollo Applications Program (AAP) as proposed by the Marshall Space Flight Center (MSFC) during a meeting held at the Manned Spacecraft Center (MSC) on September 24, 1969 are discussed in this memorandum. The writer attended this meeting with representatives from the Office of Manned Space Flight, Office of Tracking and Data Acquisition (OTDA), Goddard Space Flight Center (GSFC), MSC, and MSFC where MSFC presented two proposals for modification and partial integration of the communications systems of the AM and ATM of mission AAP-1 and MSC discussed the advantages and potential ground support cost savings in the Manned Space Flight Network (MSFN) afforded by the MSFC proposed modifications. A copy of the visual aids used during the MSC presentation are attached to this memorandum (Attachment 1). The cost figures appearing in Attachment 1 must be considered as gross estimates. At the conclusion of the meeting, it was decided that representatives of MSC and GSFC and possibly from OTDA would meet as soon as possible to refine and/or correct these cost savings estimates.

The two MSFC proposals for modification and partial integration of the current communications systems of the AM and the ATM are described in section 2.0 and the advantages and disadvantages of implementing of these proposals are discussed in section 3.0. A summary including recommendations is provided in section 4.0.

2.0 DESCRIPTION OF THE MSFC PROPOSED MODIFICATIONS

In the simpler of the two MSFC proposals (Attachment 2), the 450 MHz command receivers and the associated UHF antenna systems of the ATM and AM would be removed and redundant S-band

receivers with 70 kHz subcarrier demodulators and an S-band antenna system would be added to the AM. The composite signal output of the 70 kHz subcarrier demodulators, consisting of a 1 kHz synchronization reference tone linearly summed with a 2 kHz tone which has been phase shift keyed by digital data information, would be routed to the currently existing command decoders in the AM and the ATM. All other equipments of the communications systems of the AM, ATM, and CSM as well as the operation of these communications systems would remain unchanged.

In the second MSFC proposal (Attachment 3), the UHF command receivers of the AM and ATM, the VHF telemetry transmitters of the AM and ATM, the UHF and VHF antenna systems of the AM and ATM, the tape recorders of the AM and ATM, and the PCM telemetry system of the AM would be removed from the existing communications systems. The addition of the following equipments to the remaining equipments of the AM communications system would provide the AM with the capabilities for real-time voice communications with the MSFN, television transmission to the MSFN, and active tracking assistance to the MSFN (which is provided by the CSM in the current configuration) in addition to its current capabilities for up-data reception from, real-time and delayed-time telemetry transmission to, and delayed-time voice transmission to the MSFN:

(a) Unified S-Band (USB) system with a ranging capability which would be similar to the USB system of the CSM and would nominally be used to provide all of the communications links between the MSFN and the OA,

(b) S-band antenna system,

(c) Programmable PCM telemetry system which would combine 1.6 kilobits per second PCM bit stream from the CSM PCM telemetry system with data from the AM to form a single continuous PCM bit stream,

(d) Audio center with capabilities similar to the audio centers of the CSM,

(e) Multi-track tape recorder system with sufficient capability to support the data storage requirements for voice, experiment data, and low bit rate PCM data from the separate PCM telemetry systems of the AM and ATM, and

(f) Premodulation processor which would provide the interface between the various equipments of the AM and ATM communications systems and the USB system equipments.

In this proposal, the existing PCM telemetry system of the ATM would be retained and would be independent of the PCM telemetry system of the AM. Each system would generate a PCM bit stream for real-time transmission to the Earth and at least one PCM bit stream for on-board storage. The existing command decoders of the AM and ATM communications systems would also be retained. In this proposal, the USB communications system of the CSM would be inactive during those mission periods when the CSM is docked to the SWS. However, if high bit rate (51.2 kbps) PCM telemetry were required from the CSM during those mission periods, it would be transmitted separately to the MSFN via the USB system of the CSM.

The cost and schedule impact resulting from implementation of these two proposals would be 3.0 million dollars and 3 months delay in the arrival of the AM at Cape Kennedy for the first proposal or 24.0 million dollars and 6 month scheduled slip for the second proposal, as quoted by the McDonnell Douglas Corporation. It was estimated that approximately 4.0 million dollars could be recovered if the second proposal were implemented through cancellation of effort on the current design and implementation of the communications system of the AM. The above cost estimates are based on the use of existing hardware modified as required to meet the AAP peculiar requirements, the use of high reliability components meeting all of the usual traceability requirements, and complete qualification testing of all hardware. No development of new hardware is anticipated. Depending upon the magnitude of the modification of each piece of hardware and upon the tests already performed on each piece of hardware, full qualification testing of all equipments may not be required resulting in a reduction of the overall cost estimate. It should be noted that these costs and schedule impact estimates are very sensitive to the "go-ahead" date, increasing as the "go-ahead" date is delayed.

3.0 DISCUSSION

These proposals were made by MSFC for the dual purpose of (a) ensuring that AAP meets the date (January 1, 1975) agreed upon by NASA and the Department of Defense (DOD) for cessation of the use of frequencies in the VHF telemetry band (225 to 260 MHz) for space communications applications, and (b) possible overall NASA cost savings resulting from the elimination of selected requirements now existing in AAP for UHF command, VHF voice and telemetry, PCM telemetry decommutation, and C-band radar tracking support by stations of the Manned Space Flight Network (MSFN) and from the simplification of the required processing for post-flight data reduction. The two MSFC proposals are discussed with respect to these purposes in the following sections.

In the second MSFC proposal, it should be noted that most of the older and less reliable communications hardware obtained from the Gemini Program and used in the current communications system of the AM would be eliminated and/or replaced by more reliable hardware using solid state circuitry. However, in order to maintain sufficient circuit performance margins on the S-band communications links from the AM to stations of the MSFN, S-band power amplifiers, using traveling wave tubes (TWT's) to provide signal amplification, will be required in the AM creating some concern for overall system reliability throughout the complete mission of the SWS. A similar concern exists for the overall reliability of the data storage system of the AM although the nominal reliability of the recorder used in the NIMBUS Program (one year) which would be used in the AM substantially exceeds that of the recorders used in the Gemini Program and in the current communications system of the AM.

3.1 Vacating the VHF Telemetry Band

In view of the current schedule for mission AAP-1 through AAP-4, the current configuration of the radio frequency links of the communications systems of the AM, the ATM, and the CSM will not be affected by the requirement that NASA vacate the VHF telemetry band before January 1, 1975. However, since neither the schedule nor the configuration for the second workshop has been determined, this requirement should be a consideration in the design of the radio frequency links between the second workshop and stations of the MSFN.

If the mission of the second workshop (including a second ATM) is designated as a backup to the mission of the first workshop and the configurations of the first and second workshops will be nominally the same, it makes sense from cost effectiveness and operational experience viewpoints that modifications to the communications systems of the second workshop should also be included in the first workshop. It should be noted that vacating the VHF telemetry band for the first AAP workshop, if this were the only objective, could be accomplished more simply and cheaply than is done in the second MSFC proposal where the capabilities of the communications systems of the AM and ATM are also upgraded. If the first and second workshops (including the respective ATM's) are to have different missions and different configurations, vacating the VHF telemetry band does not appear to be a sufficient reason by itself to dictate a change in the current configuration of the communications systems of the first workshop.

3.2 Network and Data Processing Cost Savings

NASA network cost savings would be accrued by the elimination of all UHF up-data, all VHF voice and telemetry and all C-band radar tracking support requirements on the stations of the MSFN for the Orbital Assembly (OA) in AAP and by the reduction of simultaneous PCM bit stream decommutation requirements on the stations of the MSFN for the OA in AAP only if none of these support capabilities of the MSFN are required by any other NASA programs. For instance, no network cost savings would result if all VHF voice and telemetry and all C-band radar tracking support requirements for the OA were eliminated because VHF telemetry and C-band radar tracking support is required for the Saturn V Launch Vehicle in the Apollo Program and VHF voice communications support is required for the CSM in the Apollo Program. It should be noted that if there is a requirement for either VHF voice or VHF telemetry support from the MSFN, no network cost savings would result if there were no requirement for the other. In their preliminary network cost savings analysis (Attachment 1), MSC has assigned a value for network cost savings resulting from elimination in AAP of C-band tracking support requirements which will not be realized.

Elimination of the UHF up-data support requirements for the OA may result in a network cost savings if support of the UHF up-data system of the Instrument Unit (IU) of the Saturn IB Launch Vehicle during Earth orbit coast after insertion of the CSM into Earth orbit for missions AAP-2 through AAP-4 is not mandatory. UHF up-data support of the Saturn IB Launch Vehicle will be required in the launch area for range safety purposes and to provide a backup to the on-board launch vehicle computer. It does not appear that support of the UHF up-data systems of the IU of the Saturn IB Launch Vehicle in Earth orbit after separation of the CSM is mandatory, however, confirmation of this is required. The first MSFC proposal was made solely to take advantage of network cost savings provided by removal of the UHF up-data transmission capability from those stations of the MSFN which now have that capability except for those stations which support the launch phase.

In the current configuration of the communications systems of the AM, ATM, and CSM, a different PCM bit stream will be transmitted in real-time from each of these three modules and each will require real-time PCM decommutation support by the stations of the MSFN for flight control

purposes. As currently configured, each station of the MSFN has at least three PCM decommutators. However, for reliability reasons, a fourth PCM decommutator will be required at each station if decommutation support of three different PCM bit streams is required simultaneously. In the second MSFC proposal as indicated earlier, the 1.6 kbps real-time PCM telemetry bit stream will be routed to the proposed new PCM telemetry system of the AM where it will be integrated with the data from the SWS to form a single PCM bit stream containing the data required in real-time from both the CSM and the SWS. As a consequence, only two PCM bit streams will be transmitted from the OA which will require real-time decommutation support by stations of the MSFN, one from the ATM and the other from the AM. It should be noted that periodically (once per week up to once per day) the data contained in the 51.2 kbps real-time PCM telemetry bit stream will be required for flight control purposes. Since the proposed new AM telemetry system will not be capable of accommodating a 51.2 kbps PCM bit stream from the CSM, the 51.2 kbps real-time PCM telemetry bit stream from the CSM will be transmitted separately to the MSFN via the USB system of the CSM. In this case, three PCM bit streams will require real-time decommutation support by stations of the MSFN, one from the ATM, the second from the AM, and the third from the CSM. Furthermore, the CSM PCM telemetry system will be used to transmit periodically the data stored by the data systems of experiments S061-Potato Respiration and S071/072-Circadian Periodicity which will be conducted automatically on-board different CSM's of AAP. The 51.2 kbps real-time PCM telemetry bit stream must be transmitted to a station of the MSFN whenever the data stored in the data system of either one of these experiments is commanded to be dumped. The storage capacity of the data system of experiment S061 is limited to approximately 2.5 hours while that of experiments S071/072 is approximately 7.5 hours. To avoid loss of experiment data, the stored data must be dumped at lesser intervals as commanded by stations of the MSFN via the USB system of the CSM. Hence, the receive portion of the CSM USB system must remain active to enable ground control of these experiments. Therefore, it can be seen that the second MSFC proposal will not result in a reduction of the support required for decommutation of real-time PCM telemetry bit streams unless: (a) experiments S061 and S071/072 are conducted in the SWS and use the AM PCM telemetry system for transmission of their stored data dumps, and (b) the 51.2 kbps real-time PCM telemetry bit stream transmissions from the CSM for flight control purposes can be scheduled to occur over a station of the MSFN which is equipped with at least four PCM decommutators (e.g. MILA which requires four PCM decommutators to support Apollo-Saturn V launches).

In order for the task of post-flight data reduction to be simplified significantly which would result in a cost savings, the number of separate real-time and delayed-time PCM telemetry bit streams from the OA must be reduced from the current number. In the current configuration of the communications systems of the AM, ATM, and CSM, there will be one real-time PCM telemetry bit stream transmitted from each of the three modules, there will be one delayed-time PCM telemetry bit stream transmitted from the ATM, and there will be three delayed-time PCM bit streams transmitted from the AM. In the AM, one delayed-time PCM bit stream will contain housekeeping data on SWS systems and experiments, the second will contain data from various medical experiments conducted in the SWS, and the third will contain data in a time shared manner from various medical experiments, experiment M509 (Astronaut Maneuvering Equipment), experiment T013 (Crew-Vehicle Disturbance), and T020 (Foot-Controlled Maneuver Unit). From the standpoint of achieving maximum cost savings on the post-flight data reduction task, all of the data from the ATM, SWS, and CSM including experiment data transmitted in real-time to the stations of the MSFN should appear in a single real-time PCM telemetry bit stream and all of the data from the ATM, SWS, and CSM including experiment data transmitted in delayed-time should appear in a second PCM telemetry bit stream.

It appears that neither of the two MSFC proposals will result in a major simplification in the task of post-flight data reduction. As indicated earlier, the first MSFC proposal would not change the current communications systems configuration for real-time and delayed-time voice and real-time and delayed-time telemetry transmissions to stations of the MSFN. In the second MSFC proposal, some small simplification of the post-flight data reduction task would be realized by the integration of the real-time telemetry data from the CSM and the AM into a single PCM telemetry bit stream during portions of the various AAP missions. Thus the number of real-time PCM telemetry bit streams would be reduced from three to two. However, no simplification would be realized during those portions of the various AAP missions when transmission of the 51.2 kbps real-time PCM telemetry bit stream was required as discussed in the previous paragraphs.

Since it is planned that all of the telemetry and voice information stored on-board the OA will be dumped simultaneously to stations of the MSFN in the second MSFC proposal, some simplification of the data reduction task will be realized through convenience alone. In the second MSFC proposal, it is desired to integrate into a single PCM bit stream all housekeeping data on SWS systems and experiments

and all experiment data from the various medical experiments which is required for on-board storage. However, due to the large amount of data to be stored from the medical experiments (principally the three electrocardiogram measurements) and the limited bit rate record capability per channel of the recorder proposed for addition to the AM, this data may be split into two or three separate PCM bit streams. Further investigation is required in this area. Other than these one, two, or three delayed time PCM bit streams, there will be one delayed-time PCM bit stream containing data from the ATM and one delayed-time PCM bit stream containing data in a time-shared manner from experiments M509, T013, and T020.

In order to dump simultaneously all telemetry and voice information stored on-board the OA, it is planned in the second MSFC proposal to frequency multiplex the various stored PCM telemetry bit streams and the stored voice signal upon playback to form a single wideband baseband signal which would be transmitted to the stations of the MSFN via the USB system added to the AM. Since some of the telemetry and/or the voice signals will be modulated on subcarriers which could not be supported by all USB stations of the MSFN as they are currently configured, the support capabilities of the USB stations of the MSFN must be augmented to include the appropriate subcarrier demodulators. It should be noted that it is likely that some new subcarrier demodulators required for support of future missions of the Apollo Program will be added to selected USB stations of the MSFN and could provide subcarrier demodulation support for AAP.

4.0 SUMMARY

Modification and integration of the current communications systems of the AM and the ATM of mission AAP-1 to provide the capabilities to fulfill the real-time and delayed-time telemetry and voice communications, up-data, television, and tracking aid requirements of the SWS, the ATM, and the CSM with application to the second workshop appear potentially attractive from the standpoints of ground network cost savings, post-flight data reduction cost savings, reliability, and vacating the VHF telemetry band (225 to 260 MHz) before January 1, 1975. MSFC has made two proposals for modification and partial integration of the current communications systems of the AM and ATM of mission AAP-1. The first proposal would provide the AM with an S-band receiving system and the capability to receive up-data signals for both the AM and ATM up-data systems. The second proposal would provide the AM with a USB system which would nominally provide the only

communications link between the OA and stations of the MSFN and the capability for partial integration of the telemetry systems of the AM and the CSM. The cost and schedule impact resulting from implementation of either of these proposals on the first and second workshops of 3.0 million dollars and 3 months schedule slip of the first workshop and 24.0 million dollars and 6 months, respectively, quoted by McDonnell Douglas Corporation was based on the use of existing hardware modified as required, the use of high reliability components, complete qualification testing of all hardware, and getting a reasonably prompt "go-ahead", but does not include cost savings resulting from cancellation of work on the currently planned system.

Significant network cost savings (see Attachment 1) would be realized if either proposal were implemented providing that the UHF up-data system of the IU of the Saturn IB Launch Vehicles used in AAP does not require support by stations of the MSFN when coasting in Earth orbit. If Earth orbit support of the UHF up-data system of the IU is required, implementation of the first MSFC proposal would not be cost effective.

Significant network cost savings (see Attachment 1) would be realized if the number of PCM telemetry bit streams which must be decommutated simultaneously by any station of the MSFN never exceeds two. In the MSFC second proposal, the number of PCM telemetry bit streams requiring simultaneous real-time decommutation will be two only if experiments S061 and S071/072 are conducted in the SWS rather than in the CSM as now assigned and if the periodic 51.2 kbps real-time PCM telemetry bit stream transmissions from the CSM for flight control purposes can be scheduled to occur over a station of the MSFN currently possessing at least four PCM decommutators (e.g. MILA).

If the second MSFC proposal is implemented, the reliability of the communications system of the AM used to meet the communications requirements of the SWS would be enhanced because hardware from the Gemini Program (e.g. VHF transmitters, tape recorders, etc.) whose reliability in its application in the communications system of the AM is questionable over the AAP mission duration would be replaced.

Some small network cost savings and some small post-flight data reduction cost savings (see Attachment 1) would be realized if the second MSFC proposal is implemented because all of the telemetry and voice information stored on-board the OA will be dumped to the MSFN simultaneously and because the number of separate real-time and delayed-time PCM telemetry bit

streams from the OA to be processed after mission completion will be reduced slightly.

Some network cost would be incurred if the second MSFC proposal were implemented in order to provide the USB stations of the MSFN with sufficient subcarrier demodulators to support after reception the frequency multiplexed base-band signal containing all of the delayed-time telemetry and voice information transmitted from the OA.

In order to achieve major post-flight data reduction savings, all of the data from the ATM, SWS, and CSM which is required for real-time transmission to the MSFN should be combined into a single PCM bit stream and all of the data from the ATM, SWS, CSM, and experiments provided with separate data systems (M509, T013, T022, S061, and S071/072) which is stored on-board the OA should be combined into a different PCM telemetry bit stream. These two PCM telemetry bit streams would contain all of the telemetry data transmitted from the OA to the stations of the MSFN.

In view of the current schedule for missions AAP-1 through AAP-4, the first workshop will not be affected by the requirement that NASA vacate the VHF telemetry band before January 1, 1975. However, this requirement will impact the design of the radio frequency communications links of the second workshop if the mission of the second workshop could extend into or beyond 1975. It should be noted that modification of the telemetry transmission systems of the Saturn IB Launch Vehicles will also be required if they are to be used after the end of 1974 for AAP CSM launches.

It is the opinion of the writer that neither one of the two MSFC proposals should be implemented on the first workshop. Implementation of either proposal on the first workshop will not result in sufficient cost savings spread over the years through 1972 nor result in a sufficiently integrated communications system design for direct application to the second workshop to justify the large initial costs and the schedule slip for implementation on the first workshop. Consideration should be given to the implementation of an integrated telemetry system for the first and/or second work-shops which would integrate the data from the workshop and all modules docked to it (e.g. ATM, CSM) during any part of its mission into two PCM telemetry bit streams, one containing all of the real-time telemetry data and the second containing all of the delayed-time data from the OA. As a part of this consideration, the post-flight data reduction cost savings realized through reduction of the number of PCM telemetry bit

streams to be processed to a total of two should be determined. Post-flight data reduction cost savings realized in this manner would be unaffected if a USB system were included on the workshop to transmit the PCM bit streams or the VHF telemetry transmitters were retained. However, it appears prudent to replace the VHF telemetry transmitters as well as the UHF updata receivers with a USB system on the second workshop regardless of whether or not a integrated telemetry system is implemented on the second workshop. The implementation of this integrated telemetry system would be especially attractive if the operational test of the Intelsat IV relay terminal to be carried on the first workshop proves successful and is carried on the second workshop. It makes sense from cost effectiveness and operational experience standpoints to include any modifications planned for the communications system of the second workshop in the communications system of the first workshop although schedule slip may become the determining factor whether or not the modifications are incorporated into the first workshop.

A. G. Weygand

2034-AGW-mbr

A. G. Weygand

Attachments 1-3

Attachment 1

AGENDA

2 A-B-C

REVIEW OF POTENTIAL NETWORK CONFIGURATION TO SUPPORT THE S-BAND AIRBORNE TERMINAL

- - NETWORK - - OPERATIONS - - COSTS - - SUMMARY - -

MSC

AGENDA

2 A

POTENTIAL NETWORK CONFIGURATION

MSC

- LAUNCH AREA SITES

(1) • MIL
  - USB, VHF, UHB, 4 DYNA
- PAT
  - C-BAND REQUIRED

(2) • BDA
  - USB, VHF, UHF, 2 EMR, 2 DYNA
- GBM
  - DELETED
- ANT
  - DELETED

(3) • VAN
  - USB, VHF, UHV, 3 DYNA
  - C-BAND REQUIRED

- ORBITAL SITES

(4) • CYI
  - USB, VHF, UHF, 2 EMR, 1 DYNA

(5) • ACN
  - USB, VHF, UHF, 3 DYNA
- TAN
  - DELETED

(6) • MAD
  - USB ONLY, 3 DYNA

(7) ● CRO

- USB, VHF, UHF, 2 EMR, 1 DYNA
- C-BAND REQUIRED

(8) ● HSK

- USB ONLY, 3 DYNA

(9) ● GWM

- USB, VHF, UHF, 3 DYNA

(10) ● HAW

- USB, VHF, UHF, 2 EMR, 1 DYNA

(11) ● GYM

- USB, VHF, UHF, 2 EMR, 1 DYNA
- NOT REQUIRED IF TEX IS USED

(11) ● TEX

- USB, VHF, UHF, 2 EMR, 1 DYNA
- NOT REQUIRED IF GYM IS USED

(12) ● GDS

- USB ONLY, 3 DYNA
- MOVE IN CAL VHF VOICE

(13) ● SANTIAGO

- REQUIRED IF RED RELEASED
- USB, VHF, UHF

(13) ● RED

- REQUIRED IF SANTIAGO NOT AVAILABLE
- USB, VHF, UHF, 3 DYNA

SITES 13 (10 EMR'S, 31 DYNA'S UTILIZED)

AGENDA

2B

PRELIMINARY OPERATIONAL ADVANTAGES OF THE INTEGRATED S-BAND SYSTEM

MSC

- OPERATIONAL ADVANTAGES OF INTEGRATED S-BAND
  - REDUCES OPERATIONAL LINKS FROM 6 TO 2

CURRENT	PROPOSED
CSM, PM AND FM	AM, PM AND FM
AM VHF 1, 2, 3	
ATM, VHF 1, 2	(OCCASIONAL CSM)

  - DATA MANAGEMENT SIMPLIFIED
    - AIRBORNE RECORDING REQUIREMENTS REDUCED BY BEING MORE INTEGRATED
    - RECORDING MANAGEMENT SIMPLIFIED (LESS RECORDERS)
    - SITE ACQUISITION SIMPLIFIED (REDUCED CARRIERS AND DOWNLINKS)
    - ANTENNA SELECTION PROCEDURES SIMPLIFIED (LESS ANTENNAS)
  - NORMAL OPERATIONS REQUIRE ONLY 2 PCM/GS AT EACH SITE. OCCASIONAL REQUIREMENT FOR 3 PCM/GS

- OPERATIONAL ADVANTAGES OF INTEGRATED S-BAND - CONTINUED
  - SITE UTILIZATION
    - INCREASED DATA COVERAGE (85 FT SITES USED TO MAXIMUM CAPABILITY)
    - ESPECIALLY TRUE AT 50 DEGREE INCLINATION
  - CONUS PASSES
    - UTILIZATION INCREASED (TAPE DUMPS STARTED OVER GDS COMPLETED OVER GYM OR TEX)
  - TV FROM AM
    - ALLOW ATM, TV AND DATA DURING UNMANNED PHASES
  - MSFN SITE PCM/GS
    - LOAD REDUCED
    - 1 OR 2 R/T DOWNLINKS
    - STILL MAINTAIN SPARE PCM/GS
    - NEW PCM/GS UNNECESSARY
    - MAINTAIN OLD EMR'S

- OPERATIONAL ADVANTAGES OF INTEGRATED S-BAND - CONTINUED
  - MULTI-TRACK RECORDER
    - PERMITS SIMULTANEOUS RECORDING OF ALL ONBOARD ACTIVITIES - ATM LBR, AM LBR, EXPERIMENT DATA, AND VOICE
    - PERMITS SIMULTANEOUS DUMPING OF DATA WITH GOOD VOICE CORRELATION
    - ADVANTAGE REALIZED BY 160 RECORD 32:1 DUMP - VIRTUALLY ALL ATM DUMPS CAN CAN BE DONE AT NIGHT
  - EQUIPMENT RELIABILITY
    - INCREASED (NEW, MORE RELIABLE S-BAND EQUIPMENT USED - RECORDERS, ARMU'S)
  - S-BAND USES ARMU'S
    - CSM COMMUNICATION SYSTEM OFF
    - SOME POWER CONSERVATION
    - RELIABILITY INCREASED, SAVE COME-HOME SYSTEM

- OPERATIONAL ADVANTAGES OF INTEGRATED S-BAND - CONTINUED
  - S-BAND TRACKING
    - PROVIDED DURING UNMANNED PHASES
    - DISPERSIONS FOR CSM RENDEZVOUS REDUCED, BETTER TRAJECTORY DETERMINATION
  - TIMING
    - TWO TIMING SYSTEMS USED VICE THREE (NOTE: ONE IS BETTER YET)
    - FACILITATES F/C OPERATIONS
    - FACILITATES DATA REDUCTION POST MISSION
    - TIMING UPDATE PROCESS SIMPLIFIED
  - SATELLITE RELAY
    - MORE EFFICIENT UTILIZATION WITH INTEGRATED SYSTEM
    - ARMU'S USED TO SELECT DATA AREAS

- OPERATIONAL ADVANTAGES OF INTEGRATED S-BAND - CONCLUDED
  - FUNDS SPENT ON VHF WILL BE LOST
    - MUST VACATE 225 - 260 MHZ BAND BY 1975 ANYWAY
  - VHF DATA CAN BE OF REDUCED QUALITY BEYOND ≈ 750 - 1250 N. MI. SLANT RANGE
    - AS SLANT RANGE INCREASES, DATA QUALITY DECREASES
  - VHF USUALLY IS AFFECTED BY MULTIPATHING AT LOW ELEVATION ANGLES
    - USB IS NOT
  - S-BAND MORE FAMILIAR, HENCE SIMPLER SYSTEM
  - S-BAND DATA DECOM PROCESSING THRESHOLD IS BETTER THAN WITH VHF
  - VHF FREQUENCIES COULD BE GIVEN BACK TO DOD EARLY
  - LOCAL INTERFERENCE WITH VHF IS ALWAYS A PROBLEM
  - THE USB SYSTEM WOULD BE LESS SUSEPTIBLE TO SIDE LOBE PASSIVE TRACKING THAN VHF

AGENDA

ITEM 2 C

REVIEW OF

POTENTIAL NETWORK

COST SAVINGS

MSC

- AREAS OF CONSIDERATION
  - UHF COMMAND
  - VHF TELEMETRY
  - C-BAND TRACKING
  - SOFTWARE PROGRAMS
  - MAGNETIC TAPES
  - PCM GROUND STATIONS

- ASSUMPTION
  - INTEGRATED S-BAND RELIEVES REQUIREMENTS FOR:
    - UHF COMMAND
    - VHF TELEMETRY
    - C-BAND TRACKING

- UHF COMMAND COSTS
  - LAUNCH AREA SITES - 2: BDA, MIL
    - REQUIRED FOR RANGE SAFETY
    - NO SAVINGS
  - ORBITAL SUPPORT SITES - 7: CRO, CYI, ACN, HAW, GWM, GYM OR TEX, VAN (ASSUMES ANT DELETED)
    - REFURBISH FOR AAP
      - $100K PER SITE = $700K
    - M&O UNTIL AAP FLYS (2 MEN/SITE)
      - NETWORK - $300K PER YEAR
      - AAP APPROXIMATELY 3 YEARS AWAY = $900K
    - M&O DURING AAP (3 MEN/SITE)
      - NETWORK - 450K PER YEAR = $450K

- UHF COMMAND COSTS - CONTINUED:
  - SUMMARY:

	AAP 1 - 4	AAP 1 - 8
- REFURBISH 7 SITES	$ 700K	$ 700K
- INACTIVE M&O, 1969 TO 1972	900K	900K
- ACTIVE M&O, 1972	450K	450K
- ACTIVE M&O, 1973 TO 1974		900K
	$ 2,050K	$ 2,950K

- VHF TELEMETRY COSTS
  - LAUNCH PHASE
    - REQUIRED FOR LAUNCH VEHICLE
    - NO SAVINGS
  - ORBITAL OPERATIONS - 9 SITES: MIL, BDA, ACN, CYI, VAN, CRO, GWM, HAW, GYM OR TEX
    - NO SUPPORT REQUIRED
    - COST (3 MEN/SITE) $60K PER YEAR = $540K
    - SAVINGS NONE
  - VHF REQUIRED BY APOLLO AND AAP BOOSTER

- C-BAND TRACKING COSTS
  - APPLICABLE SITES
    - CNV, PAT, VAN, CRO
  - BREAKDOWN
    - CNV - USED FOR WEATHER
    - VAN - MIN NETWORK SUPPORT
    - CRO-PAT - MIN NETWORK SUPPORT
- C-BAND SITE COSTS (ANNUAL)
  - PERSONNEL, OPS AND SPARES
    - CRO $ 400K
    - PAT $ 300K
    - VAN $ 250K

- C-BAND IS ONLY REQUIRED FOR SKIN TRACKING OBJECTS IN MANNED SPACEFLIGHT (i.e., WORKSHOP WITH NO TRANSPONDER)

- IF C-BAND SKIN TRACKING WERE ONLY REQUIRED FOR AAP WORKSHOP, THEN C-BAND COULD BE ELIMINATED WITH THESE RESULTANT SAVINGS:

1970	950K
1971	950K
1972 AAP 1-4	950K
1973	950K
1974 AAP 1-8	950K

AAP 1-4	AAP 1-8
$ 2,850K	$ 4,750K

- SOFTWARE CHANGES

  - NO APPARENT DIFFERENCE, IF FIXED FORMATS ARE USED IN COST STUDY, WHETHER PRESENT SYSTEM OR S-BAND IS USED

  - APPLIES TO:

    - RTCC
    - CCATS
    - RSDP

- MAGNETIC RECORDING TAPES

ITEM	CURRENT SYSTEM COST	USB SYSTEM COST	SAVINGS
• ANALOG TAPES	$1,146,950	$622,630	$524,320
• DIGITAL TAPES	25,051	18,559	6,492
• PROGRAM DEVELOPMENT	———	———	———
• SIGNAL PROCESSING COMPUTER TIME	577,930	422,305	155,625
• CENTRAL PROCESSING TIME	426,312	336,514	89,798

TOTAL TAPE SAVINGS FOR 1 WORKSHOP APPROXIMATELY $776,000

TOTAL TAPE SAVINGS FOR 2 WORKSHOPS APPROXIMATELY $1,552,000

- PCM GROUND STATION COSTS
  - MSFN SITES HAVE THREE PCM/GS PER SITE
  - CONVENTIONAL AAP COMM WILL TAX PCM/GS OPERATIONS
    - NO SPARE PCM/GS
    - GSFS MAY REQUIRE ADDITIONAL PCM/GS PER SITE
    - UPGRADING COULD REQUIRE 16 NEW PCM/GS
    - COST $ 100K PER PCM/GS
- SUMMARY

	AAP 1-4	AAP 1-8
4TH PCM/GS	$ 1,600K	$ 1,600K
TOTAL	$ 1,600K	$ 1,600K

- ADDITIONAL POSSIBLE COST SAVINGS
  - DO NOT ACTIVATE SANTIAGO UHF
    - ACTIVATION COST (NEW GEAR) 450K
    - OPERATIONS COST PER YEAR 60K

SUMMARY:

	AAP 1-4	AAP 1-8
ACTIVATION	450K	450K
1972 OPERATIONS	60K	
1973-74 OPERATIONS		180K
TOTAL	$ 510K	$ 630K

- ADDITIONAL POSSIBLE COST SAVINGS - CONTINUED
  - DO NOT ACTIVATE SANTIAGO VHF
    - ACTIVATION COST 373K
    - OPERATIONS COST PER YEAR 60K

SUMMARY:

	AAP 1-4	AAP 1-8
ACTIVATION	373K	373K
1972 OPERATIONS	60K	
1972 - 74 OPERATIONS		180K
TOTAL	$ 433K	$ 553K

COST SUMMARY

	AAP 1-4	AAP 1-8
UHF COMMAND	$ 2,050K	$ 2,950K
VHF TELEMETRY C-BAND TRACKING	$ 2,850K	$ 4,750K
SOFTWARE MAGNETIC TAPES	776K	$ 1,552K
SUBTOTAL	$ 5,676K	$ 9,252K
PCM GROUND STATIONS	$ 1,600K	$ 1,600K
SUBTOTAL	$ 7,276K	$ 10,852K
SANTIAGO UHF	510K	630K
SANTIAGO VHF	433K	553K
SUBTOTAL	$ 8,219K	$ 12,035K

TOTAL COST SAVINGS COULD APPROACH $ 12M

SUMMARY

- SUMMARY
  - TO FULLY REALIZE THE OPERATIONAL ADVANTAGES AND COST SAVINGS IDENTIFIED, AN AIRLOCK UNIFIED S-BAND SYSTEM SHOULD REFLECT THE FOLLOWING CAPABILITIES:
    (1) AM RT DATA, ATM RT DATA, AND CSM LBR DATA ALL COMBINE IN ONE DOWNLINK
    (2) ONBOARD RECORDED DATA - PSF, SF 2, SF 3, VOICE AND ATM RECORDED - ALL DUMPED ON SUBCARRIERS SIMULTANEOUSLY
    (3) ALL ONBOARD DATA RECORDED ON A MULTI-TRACK RECORDER
    (4) COMMON TIMING SYSTEM USED FOR AM AND ATM
  - CURRENT UNIFIED S-BAND PROPOSAL DOES NOT
    (1) COMBINE AM AND ATM DATA
    (2) USE COMMON TIMING

    PROBLEM:

    REQUIRES REDESIGN OF ATM
  - IF TOTAL INTEGRATION CANNOT BE OBTAINED ON WORKSHOP 1, USE PROPOSED S-BAND SYSTEM. THEN DESIGN TOTAL INTEGRATION INTO WORKSHOP 2

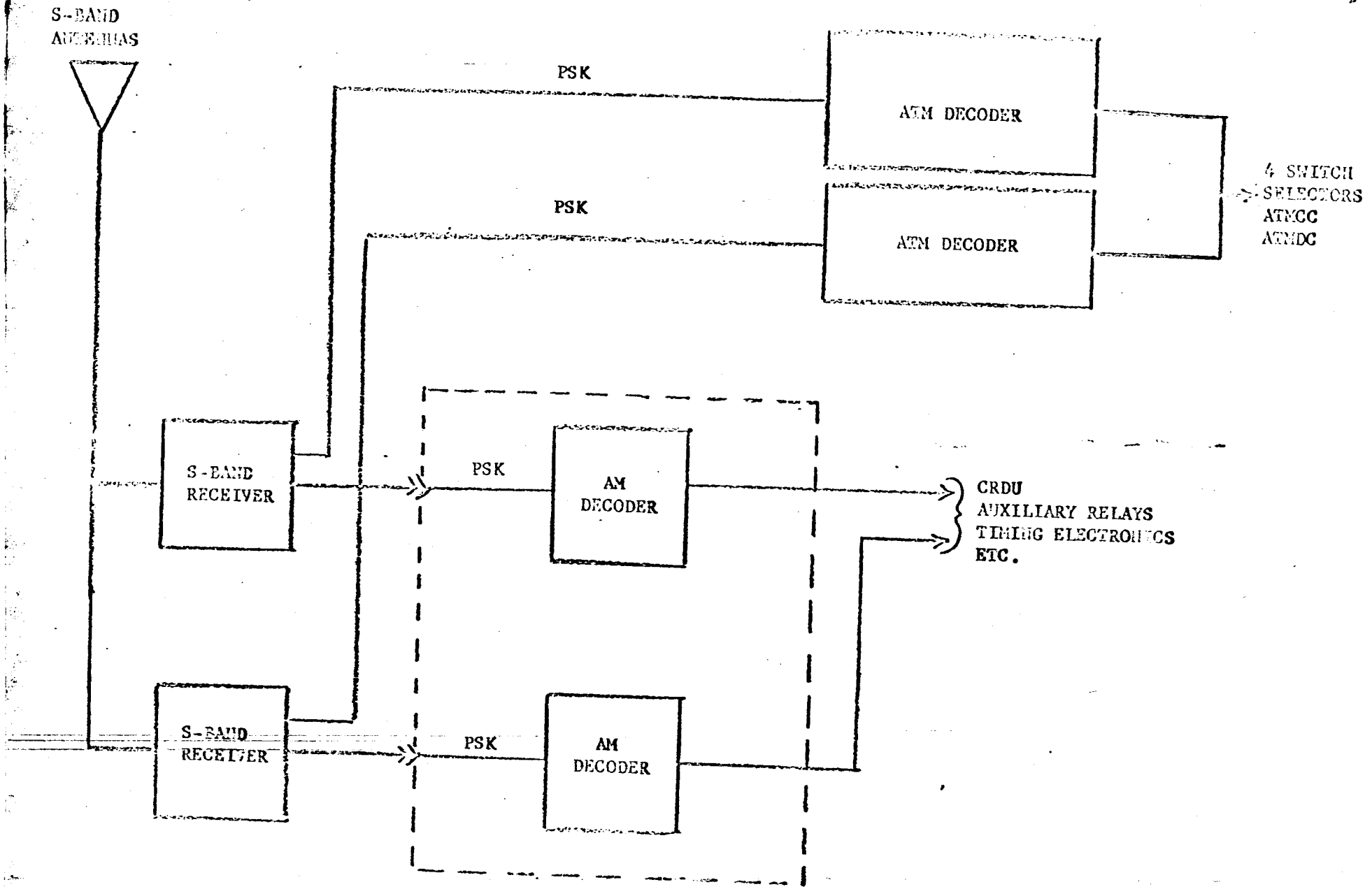
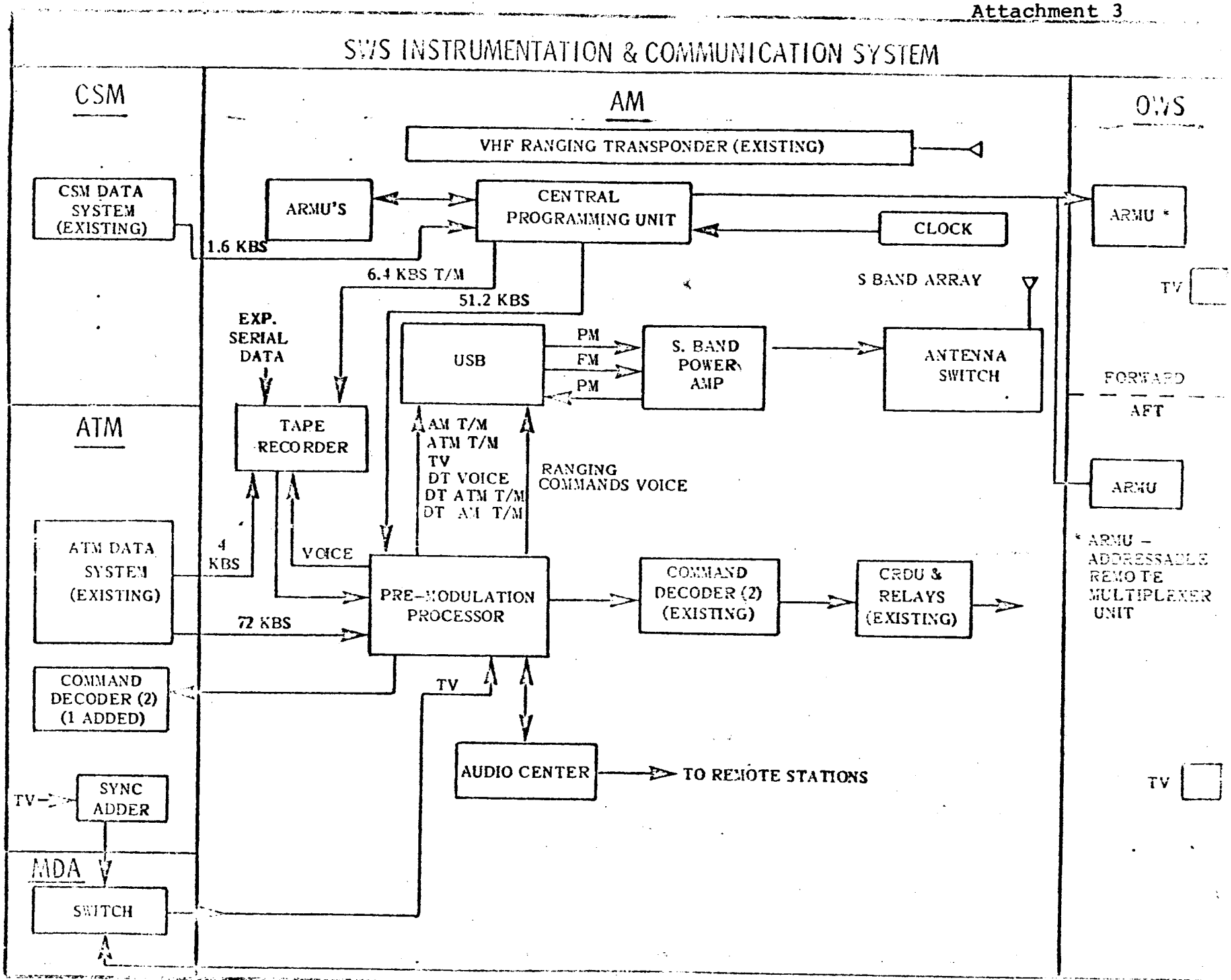


FIGURE 2. RECONFIGURED COMMAND SYSTEM


SWS INSTRUMENTATION & COMMUNICATION SYSTEM
CSM
AM
OWS
VHF RANGING TRANSPONDER (EXISTING)
CSM DATA SYSTEM (EXISTING)
ARMU'S
CENTRAL PROGRAMMING UNIT
CLOCK
ARMU *
1.6 KBS
6.4 KBS T/M
51.2 KBS
S BAND ARRAY
TV
EXP. SERIAL DATA
USB
PM
FM
PM
S. BAND POWER AMP
ANTENNA SWITCH
FORWARD
AFT
ATM
TAPE RECORDER
AM T/M
ATM T/M
TV
DT VOICE
DT ATM T/M
DT AM T/M
RANGING COMMANDS VOICE
ARMU
ATM DATA SYSTEM (EXISTING)
4 KBS
VOICE
PRE-MODULATION PROCESSOR
COMMAND DECODER (2) (EXISTING)
CRDU & RELAYS (EXISTING)
72 KBS
* ARMU - ADDRESSABLE REMOTE MULTIPLEXER UNIT
COMMAND DECODER (2) (1 ADDED)
TV
AUDIO CENTER
TO REMOTE STATIONS
TV
SYNC ADDER
TV
MDA
SWITCH

BELLCOMM, INC.

Subject: Discussion of Proposed Changes to the Communications Systems of the AM and ATM in AAP - Case 620

From: A. G. Weygand

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